

Effect of detachment on Magnum-PSI ELM-like pulses

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Reducing divertor target heat loads is required for a tokamak reactor and there is much that remains to be understood about detachment in reducing those heat loads. One less-studied aspect of detachment is the impact of ELMs on on detachment. The transient heat loads associated with ELMs lead to a temporary reattachment of the plasma to the target which corresponds to increased heat and particles fluxes. We study ELMs and the role of atomic and molecular driven processes using the Optical Emission Spectroscopy (OES) diagnostic to resolve inter-ELM Balmer line emission in the linear plasma device Magnum-PSI in conjunction with Thomson scattering (TS). [1] The ELM-like pulses were performed in a pure hydrogen plasma for various magnetic field strengths, target chamber pressures. OES and TS observations were made at a fixed point in space for different locations of the target along Magnum-PSI axis. [2]

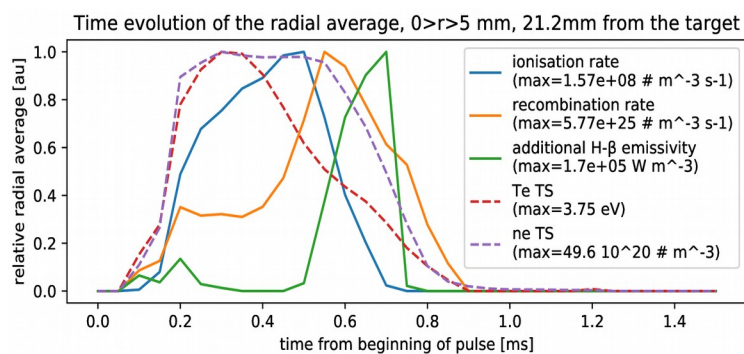


Figure 1: Example of the time evolution of the ELM-like pulse for target chamber pressure 15Pa, magnetic field 1.3T, distance from the target 21.2mm.

Deeply detached conditions are achieved through hydrogen injection into the target chamber. We find that emissivity of the $n=4 \rightarrow 2$ Balmer line ($H\beta$) is enhanced over what an atomic collisional-radiative model (ADAS [3]) would predict (excitation and recombination) based on high n Balmer line intensities ($n > 5 \rightarrow 2$). The additional $H\beta$ emissivity accounts for up to $\sim 80\%$ of the total OES $H\beta$ measurement and appears to be localised in a region of the plasma where the temperature lies between 0.5 and 2.5eV, a range where molecular activated recombination (MAR) is expected to be a relevant population mechanism for low excited states. [2] It is observed that electron density and ionisation rate are higher close to the target, possible markers of neutrals generated at the target being locally ionised in front of it, similar to what is observed in tokamaks. During the ELM-like pulses it is observed that the plasma transitions first to being strongly ionising as it burns through the background neutrals in front to the target, to the point of reattaching. Then the plasma cools and the plasma near the target transitions back to recombining. Finally, MAR related emission appears to peak as the detachment front is pushed back to steady state detached conditions.

To go beyond the prediction of atomic processes to include molecular effects (contributions to Balmer line intensities due to reactions involving H_2 , H_2^+ , H_3^+ and H^-), we will utilize the more-detailed Yacora CR model. [4]

[1] H. Van Eck, PhD thesis, Technische Universiteit Eindhoven, 2013.

[2] R. Barrois, W. Vijvers, I. Classen, R. Jaspers, R. Engeln, PhD thesis, Technische Universiteit Eindhoven, 2017.

[3] H. Summers, M. O'Mullane, JET Joint Undertaking Report JET-P9735 (2000).

[4] W. Dirk, and U. Fantz, Atoms 4.4 (2016): 26.